

WATER POSSIBILITIES FROM THE  
GLACIAL DRIFT OF  
LINN COUNTY

BY

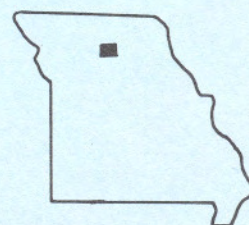
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Water Resources Report 11

WATER POSSIBILITIES FROM THE GLACIAL DRIFT  
OF LINN COUNTY

By Dale L. Fuller, James Martin, Harry Pick,  
W. B. Russell, and Jack Wells



1957

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MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES    ROLLA, MO.

William C. Hayes, State Geologist and Director

## WATER POSSIBILITIES FROM THE GLACIAL DRIFT OF LINN COUNTY

A special study of groundwater by the Missouri Geological Survey and Water Resources was made possible at the 1955 session of the Missouri Legislature. With the approval of the Governor, money was appropriated from the Missouri Post War Surplus Reserve Fund.

Since nearly two-thirds of the counties located north of the Missouri River are deficient in water supplies, much of the effort of this special study is being directed toward the problems of this area.

It has been shown that a program of test drilling can locate new reserves of groundwater. Potential areas are being tested so that additional supplies will be available for domestic, irrigation, industrial and municipal needs.

The most favorable areas are in the sand and gravel filled channels and valleys of pre-glacial and inter-glacial streams. Since these buried valleys do not conform to present day drainage patterns, a systematic program of test drilling is a principal means of locating the channels and mapping their extent. Such glacial deposits have proved to be excellent sources of groundwater.

## QUALITY OF WATER FROM ROCK WELLS

The water from the consolidated rock formations which underlie Linn County is, for the most part, mineralized. The following are analyses from water wells and oil tests.



CONSTITUENTS	IN PARTS PER MILLION			
	A	B	C	D
Turbidity	15	25	slight	
Odor	none	none	none	
pH	7.85	7.6		
Alkalinity (CaCO <sub>3</sub> )	737.0	391.0	460.7	
Phenolphthalein	80.0	48.0		
Methyl Orange	657.0	343.0		
Carbonate (CO <sub>3</sub> )	48.0	28.8	17.6	
Bicarbonate (HCO <sub>3</sub> )	801.5	418.5	561.8	326.1
Silica (SiO <sub>2</sub> )	4.0	5.5	8.0	3.6
Oxides (Al <sub>2</sub> O <sub>3</sub> , Fe <sub>2</sub> O <sub>3</sub> , TiO <sub>2</sub> , etc.)	1.0	1.5	0.04*	
Calcium (Ca)	17.9	83.7	20.1	353.6
Magnesium (Mg)	12.6	45.8	9.6	148.0
Sodium (Na) & Potassium (K) as Na	1812.9	2396.7	924.5	1845.7 <sup>1</sup>
Total Manganese (Mn)	0.04	0.05	0.04	
Total Iron (Fe)	2.18	3.44	4.05	
Dissolved Iron	0.02	0.62	0.25	
Precipitated Iron	2.16	2.82	3.80	
Sulfate (SO <sub>4</sub> )	119.5	987.7	1343.7	1202.2
Chloride (Cl)	2410.0	3060.0	211.0	2832.3
Nitrate (NO <sub>3</sub> )	0.0	0.1	1.90	0.4
Fluoride (F)	1.4	1.4	3.60	
Total Suspended Matter	---	0.	26.0	
Total Dissolved Solids	4896.	6787.	2746.0	6808.0
Total Hardness	96.6	397.5	89.6	1490.0
Carbonate Hardness	96.6	391.0	89.6	
Non-carbonate Hardness	0.0	6.5		
Percent of Alkalies	98	93	96	73

\* Al<sub>2</sub>O<sub>3</sub> only

<sup>1</sup> Sodium (Na) only

A. Owner: Oscar A. Thorn, SW $\frac{1}{4}$  NW $\frac{1}{4}$  NW $\frac{1}{4}$  sec. 29, T. 59N., R. 21W. Total depth 400 feet (?). Sample collected from pump February 5, 1957. Temperature of water 55°F., of the air 45°F. Analyst: M. E. Phillips.

B. Owner: R. E. Dolan, NE $\frac{1}{4}$  NE $\frac{1}{4}$  SE $\frac{1}{4}$  sec. 5, T. 58N., R. 21W. Total depth 565 feet. Sample collected from pump February 5, 1957. Temperature of water 52°F., of the air 45°F. Analyst: M. E. Phillips.

C. Owner: Greely Moore, on line SE $\frac{1}{4}$  sec. 4, T. 58N., R. 20W. Total depth 350 feet probably into Cherokee of the Pennsylvanian System. Analyzed July 30, 1935 by R. T. Rolufs.

D. Owner: McDonald Brothers, NW $\frac{1}{4}$  sec. 12, T. 57N., R. 21W. Total depth 190 feet. Production 15 gallons from Cherokee sand source. Analyzed September 11, 1914.

CONSTITUENTS	IN PARTS PER MILLION		
	E	F	G
Turbidity	turbid	sediment	
Odor	none	none	
pH		7.95	
Alkalinity (CaCO <sub>3</sub> )	311.4	707.5	
Phenolphthalein		44.0	
Methyl Orange		663.5	
Carbonate (CO <sub>3</sub> )	14.8	26.4	88.4
Bicarbonate (HCO <sub>3</sub> )	379.7	809.5	
Silica (SiO <sub>2</sub> )	10.4	5.2	44.7
Oxides (Al <sub>2</sub> O <sub>3</sub> , Fe <sub>2</sub> O <sub>3</sub> , TiO <sub>2</sub> , etc.)	0.19*	1.2	40.3
Calcium (Ca)	45.2	20.6	624.4
Magnesium (Mg)	26.0	10.1	289.2
Sodium (Na) & Potassium (K) as Na	448.5	793.1	4091.7 <sup>1</sup>
Total Manganese (Mn)			
Total Iron (Fe)	4.35	0.09	
Dissolved Iron	0.15		
Precipitated Iron	4.20		
Sulfate (SO <sub>4</sub> )	268.3	252.3	1222.8
Chloride (Cl)	385.3	508.8	7267.3
Nitrate (NO <sub>3</sub> )	2.63		
Fluoride (F)			
Total Suspended Matter	29.6		
Total Dissolved Solids	1407.0	1966.	
Total Hardness	219.6	93.0	2751.7
Carbonate Hardness	219.6	707.5	
Non-carbonate Hardness			
Percent of Alkalies	82	95	76

\*Al<sub>2</sub>O<sub>3</sub> only

<sup>1</sup> Sodium (Na) only

E. Owner: Henderson Produce Company, NE $\frac{1}{4}$  SW $\frac{1}{4}$  sec. 5, T. 57N., R. 20W. Total depth 260 feet bottomed seven feet into a Mississippian System limestone. Analyzed August 17, 1935 by R. T. Rolufs.

F. Owner: B. A. Ewigman, NW $\frac{1}{4}$  NW $\frac{1}{4}$  NW $\frac{1}{4}$  sec. 30, T. 57N., R. 18W. Total depth 290 feet. Collected May 20, 1953. Analyst: M. E. Phillips.

G. Owner: George W. Early, et al; Marceline Gas, Oil and Development Company, SW $\frac{1}{4}$  NW $\frac{1}{4}$  SE $\frac{1}{4}$  sec. 30, T. 57N., R. 18W. Total depth 2,004 feet.

Referring to Plate 1, it will be noted that a large area of Linn County is unfavorably located to obtain water from glacial drift. Wells drilled

into the consolidated rock to moderate depths may possibly obtain limited yields of water of marginal quality. The water from "rock" wells in all probabilities will become more mineralized with increased depth of drilling.

#### QUALITY AND QUANTITY OF WATER FROM STREAMS

The streams of Linn County, are intermittent or in the case of some very limited in their flow during dry weather. Although the quality of the water is usually satisfactory, the undependable flow makes all streams unsuitable for irrigation or for municipal use.

One water analyses is available. The sample was collected from Locust Creek in sec. 27, T. 59N., R. 21W., west of Linneus. At the date collected, November 21, 1955, the stage was 3.28 feet. Water temperature 48°F., of the air 60°F. Analyst: M. E. Phillips.

CONSTITUENTS	IN PARTS PER MILLION
Turbidity	10
Odor	none
pH	8.2
Alkalinity (CaCO <sub>3</sub> )	164.0
Phenolphthalein	7.0
Methyl Orange	157.0
Carbonate (CO <sub>3</sub> )	4.2
Bicarbonate (HCO <sub>3</sub> )	191.5
Silica (SiO <sub>2</sub> )	8.0
Oxides (Al <sub>2</sub> O <sub>3</sub> , Fe <sub>2</sub> O <sub>3</sub> , TiO <sub>2</sub> , etc.)	1.2
Calcium (Ca)	58.1
Magnesium (Mg)	11.1
Sodium (Na) & Potassium (K) as Na	16.6
Total Manganese (Mn)	3.28
Total Iron (Fe)	1.01
Dissolved Iron	0.07
Precipitated Iron	0.94
Sulfate (SO <sub>4</sub> )	42.5
Chloride (Cl)	4.8
Nitrate (NO <sub>3</sub> )	0.0
Fluoride (F)	0.2

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**CONSTITUENTS**
**IN PARTS PER MILLION**


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Total Suspended Matter	13.
Total Dissolved Solids	252.
Total Hardness	190.8
Carbonate Hardness	164.0
Non-carbonate Hardness	26.8
Percent of Alkalies	16

The following are stream flow data from: Bolon, Harry C., Surface Waters of Missouri; Missouri Geological Survey and Water Resources, 2d ser., vol. 34, p. 370 and 379, 1952.

**Locust Creek near Linneus**

Location. - Wire-weight gage, lat. 39°53', long. 93°14' in NE¼ sec. 34, T. 59N., R. 21W., at county highway bridge, 3 miles northwest of Linneus and 4 miles downstream from confluence of East and West Locust Creeks. Datum of gage is 692.61 feet above mean sea level, datum of 1929.

Drainage Area. - 550 square miles.

Records Available. - April 1929 to September 1949.

Average Discharge. - 20 years, 323 second-feet.\*

Extremes. - 1929-49: Maximum discharge, 38,000 second-feet June 6, 1947 (gage height, 26.93 feet, from floodmarks), by slope-area method; no flow July 17, to August 11, 1934.

Remarks. - Records, in general, are fair except those for periods of ice effect, which are poor.

Revisions. - Revised figures of discharge for the water year 1939, superseding those published in "Surface Waters of Missouri, 1929-1939" Vol. XXVI, Second Series, are given herein.

\* One second-foot equals 448.83 gallons per minute.

**Yellow Creek near Rothville, Chariton County.**

Location. - Wire-weight gage, lat. 39°38', long. 93°05', on line between NW¼ sec. 31, T. 56N., R. 19W., and NE¼ sec. 36, T. 56N., R. 20W., at bridge on State Highway 11, 2½ miles southwest of Rothville and 3 miles downstream from East Yellow Creek. Datum of gage is 664.37 feet above mean sea level, datum of 1929. Chain gage at same site and datum used April 1929 to June 1932.

Drainage Area. - 405 square miles (revised).

Records Available. - April 1929 to June 1932, October 1948 to September 1949.

Extremes. - 1929-32, 1948-49: Maximum discharge, 74,000 second-feet November 25, 1931, June 3, 1949; maximum gage height, 21.19 feet June 3, 1949; minimum daily discharge, 0.2 second-foot October 1-4, 25-28, 30, 31,

1948.

Maximum stage known, 23.1 feet in June 1947, from floormark, from information by Corps of Engineers and local residents.

Remarks. - Records fair except those below 10 second-feet and those for periods of ice effect or no gage-height record, which are poor.

Cooperation. - Station maintained by Surface Water Branch United States Geological Survey in cooperation with Corps of Engineers.

#### QUALITY OF WATER FROM GLACIAL DRIFT

In general, the water from the glacial drift is high in total iron, total dissolved solids, and sulfates. The iron content in the water may cause staining of plumbing fixtures and laundry; however, relatively inexpensive water treatment for the iron will prevent this staining. For most types of irrigation, total dissolved solids should not exceed 2,000 parts per million and total alkalies should not exceed 75 percent. Most people cannot tolerate water for drinking purposes which contains more than 1,500 parts per million of chloride, or 2,000 parts per million sulfate. Water with 300 parts per million of chloride tastes salty to some people. Sulfates in excess of 500 parts per million may have a laxative effect when first used for drinking.

The following are analyses from eight glacial drift wells.

CONSTITUENTS	IN PARTS PER MILLION			
	1	2	3	4
Turbidity	60	60	25	slight
Odor	Pickles*	Pickles*	none	none
pH	8.6	8.6	7.4	
Alkalinity (CaCO <sub>3</sub> )	187.0	166.0	387.0	339.9
Phenolphthalein	0	0	28.0	
Methyl Orange	187.0	166.0	359.0	
Carbonate (CO <sub>3</sub> )	0	0	16.8	13.5
Bicarbonate (HCO <sub>3</sub> )	227.5	202.0	438.0	414.5
Silica (SiO <sub>2</sub> )	20.0	20.0	11.3	26.8
Oxides (Al <sub>2</sub> O <sub>3</sub> , Fe <sub>2</sub> O <sub>3</sub> , TiO <sub>2</sub> , etc.)			1.3	1.89 <sup>1</sup>



CONSTITUENTS	IN PARTS PER MILLION			
	1	2	3	4
Calcium (Ca)	51.0	59.5	142.5	140.6
Magnesium (Mg)	12.1	15.6	54.0	48.1
Sodium (Na) & Potassium (K) as Na	23.1	27.5	228.2	142.1
Total Manganese (Mn)			0.05	
Total Iron (Fe)	10.0	5.0	4.06	2.48
Dissolved Iron			0.13	0.08
Precipitated Iron			3.93	2.40
Sulfate (SO <sub>4</sub> )	26.1	57.6	567.7	440.5
Chloride (Cl)	12.3	34.6	27.5	13.3
Nitrate (NO <sub>3</sub> )	2.22	0.44	2.4	44.28
Fluoride (F)	0.1		0.4	0.80
Total Suspended Matter	0	0	0	150.0
Total Dissolved Solids	275.0	253.0	1319.	1229.0
Total Hardness	180.0	224.0	578.1	548.7
Carbonate Hardness	180.0	166.0	387.0	339.9
Non-carbonate Hardness	0.0	58.0	191.1	208.8
Percent of Alkalies	22	22	46	36

\* Water collected in pickle jar

1 Al<sub>2</sub>O<sub>3</sub> only

1. Owner: City of Browning. "New well #1. 80 feet east of C. B. & Q. Tracks; 70 feet south of Main Street". Sampled June 16, 1955. Analyzed by the Missouri Division of Health.

2. Owner: City of Browning. "New well #2. 60 feet east of C. B. & Q. Tracks, and 60 feet south of D. Street. Sampled June 16, 1955. Analyzed by Missouri Division of Health.

3. Owner: D. A. Falconer, NW $\frac{1}{4}$  NW $\frac{1}{4}$  NW $\frac{1}{4}$  sec. 9, T. 59N., R. 21W. Total depth 147 feet. Static water level 92 feet. Sampled direct from pump February 5, 1957. Temperature of water 53°F., of the air 42°F. Analyst: M. E. Phillips.

4. Owner: CCC Camp, Linneus, Missouri. Total depth 25 feet. Analyzed July 30, 1935 by R. T. Rolufs.

CONSTITUENTS		IN PARTS PER MILLION			
		5	6	7	8
Turbidity	Turbid		2	25	50
Odor	Musty		none	none	none
pH			7.5	7.5	7.6
Alkalinity (CaCO <sub>3</sub> )		227.7	442.5	431.5	490.5
Phenolphthalein			14.0	0.0	12.0
Methyl Orange			428.5	431.5	478.5
Carbonate (CO <sub>3</sub> )		12.1	8.4	0.0	7.2
Bicarbonate (HCO <sub>3</sub> )		338.7	522.8	526.4	583.8
Silica (SiO <sub>2</sub> )		3.2	13.3	18.7	10.0
Oxides (Al <sub>2</sub> O <sub>3</sub> , Fe <sub>2</sub> O <sub>3</sub> , TiO <sub>2</sub> , etc.)		0.26 <sup>1</sup>	0.7	1.0	0.7
Calcium (Ca)		89.6	69.7	60.4	83.0
Magnesium (Mg)		26.0	25.8	24.2	28.2
Sodium (Na) & Potassium (K) as Na		44.5	105.8	144.8	131.8
Total Manganese (Mn)		0.00	0.05	0.04	0.05
Total Iron (Fe)		1.60	0.38	3.06	4.94
Dissolved Iron		0.10	0.04	0.21	0.22
Precipitated Iron		1.50	0.34	2.85	4.72
Sulfate (SO <sub>4</sub> )		121.3	15.6	29.2	18.7
Chloride (Cl)		6.4	21.0	60.0	46.0
Nitrate (NO <sub>3</sub> )		1.27	1.2	0.9	0.0
Fluoride (F)		0.65	0.3	0.3	0.1
Total Suspended Matter		125.4	0.	5.	9.
Total Dissolved Solids		546.0	515.	602.	604.
Total Hardness		330.6	280.3	250.4	323.4
Carbonate Hardness		227.7	280.3	250.4	323.4
Non-carbonate Hardness		102.9	0.0	0.0	0.0
Percent of Alkalies		23	45	56	47

<sup>1</sup> Al<sub>2</sub>O<sub>3</sub> only

5. Owner: Linneus School well. Total depth 75 feet. Analyzed July 30, 1935 by R. T. Rolufs.

6. Owner: Meadville City well. NW $\frac{1}{4}$  NE $\frac{1}{4}$  SW $\frac{1}{4}$  sec. 6, T. 57N., R. 21W. Total depth 85 feet. Sampled direct from pump February 4, 1957. Analyst: M. E. Phillips.

7. Owner: Lewis Schuetz, SE $\frac{1}{4}$  SE $\frac{1}{4}$  sec. 13, T. 57N., R. 22W. Total depth 175 feet. Sampled from pressure tank February 4, 1957. Analyst: M. E. Phillips.

#### QUANTITY OF WATER FROM GLACIAL DRIFT

DOMESTIC WELLS - Included in this category are wells developed for house-

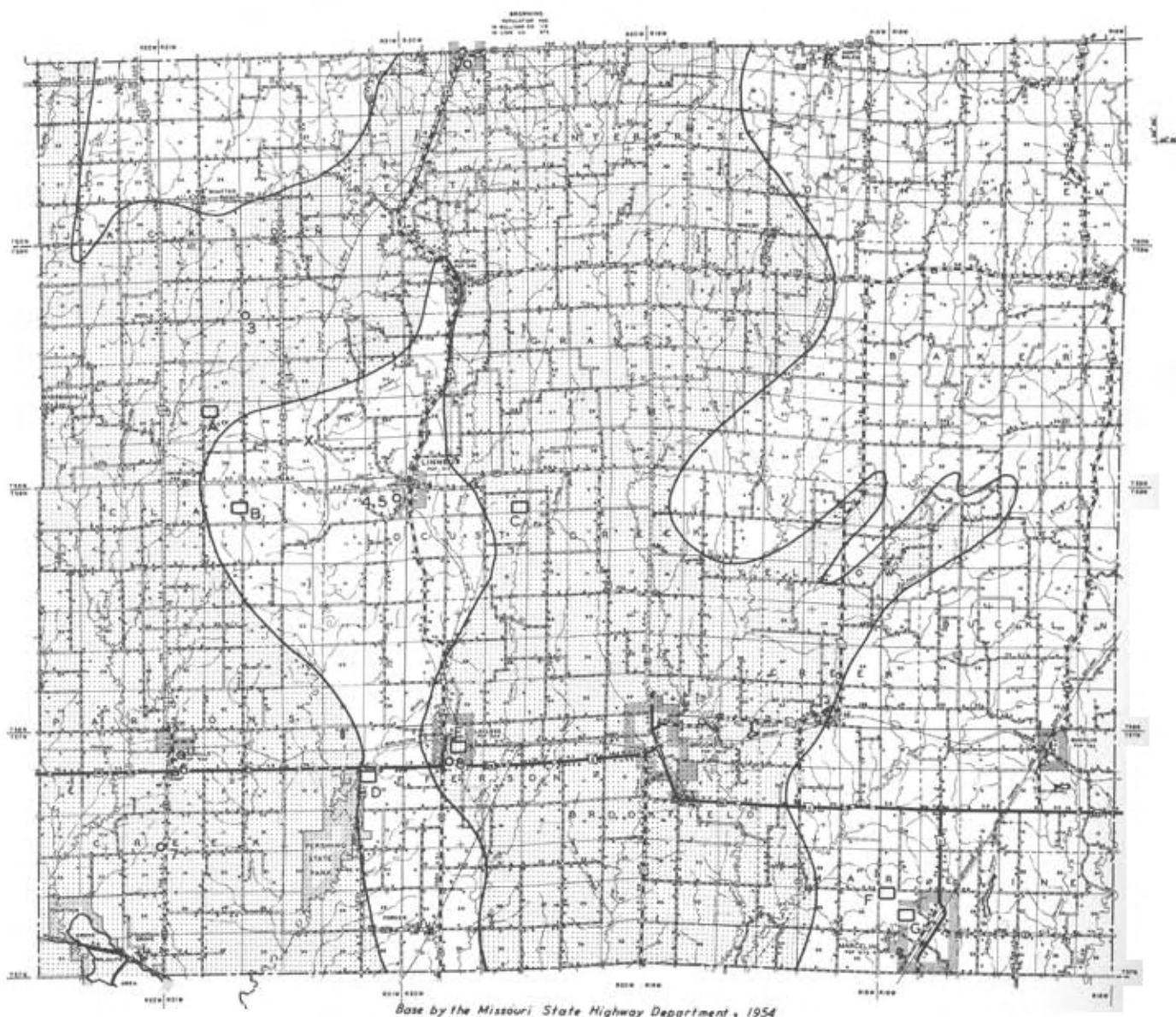
hold or general farm use. Yields required from domestic wells vary but seldom exceed 15 gallons per minute. In some parts of Linn County sands and gravels were not deposited in the glacial drift. There are also areas where the glacial drift cover is relatively thin or lacking. In such areas the possibility of developing wells is limited. Plate 1 shows the area most favorable for the development of domestic wells. Plate 3 is a contour map showing the elevation of bedrock above sea level. To determine probable drilling depths, the elevation of the bedrock should be subtracted from the surface elevation for each specific site. Plate 3 shows the locations of the test holes and the thickness of the glacial drift encountered.

IRRIGATION WELLS - Included in this category are all high yield wells whether used by cities, by industries, or for irrigation. Plate 2 shows the area most favorable for the development of irrigation wells. Also shown are the locations of three tests which flowed. With proper development, yields of 200-1,000 gallons per minute may be obtained. Yields to be expected are contingent upon several factors:

- (1) The thickness of the sand and gravel beds.
- (2) The size and sorting of the sand and gravel.
- (3) The manner of construction and materials used, such as proper well screen, gravel pack, etc.
- (4) Ability of the well driller to develop the full capacity of the water bearing sands.

Continued successful production is contingent upon:

- (1) Re-charge rate of the water-bearing horizons.
- (2) Quality of the screen and materials used.
- (3) Subsequent well treatment such as acidizing.
- (4) Avoidance of over-pumpage.



Base by the Missouri State Highway Department, 1954

# LEGEND



Area most favorable

O4

Location of wells in drift from which water was analyzed

□H

Water sample analyzed from a "rock" well

X

Water sample analyzed from a stream

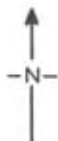


PLATE I

## MAP OF LINN COUNTY

SHOWING

AREA MOST FAVORABLE FOR THE DEVELOPMENT OF WELLS IN DRIFT

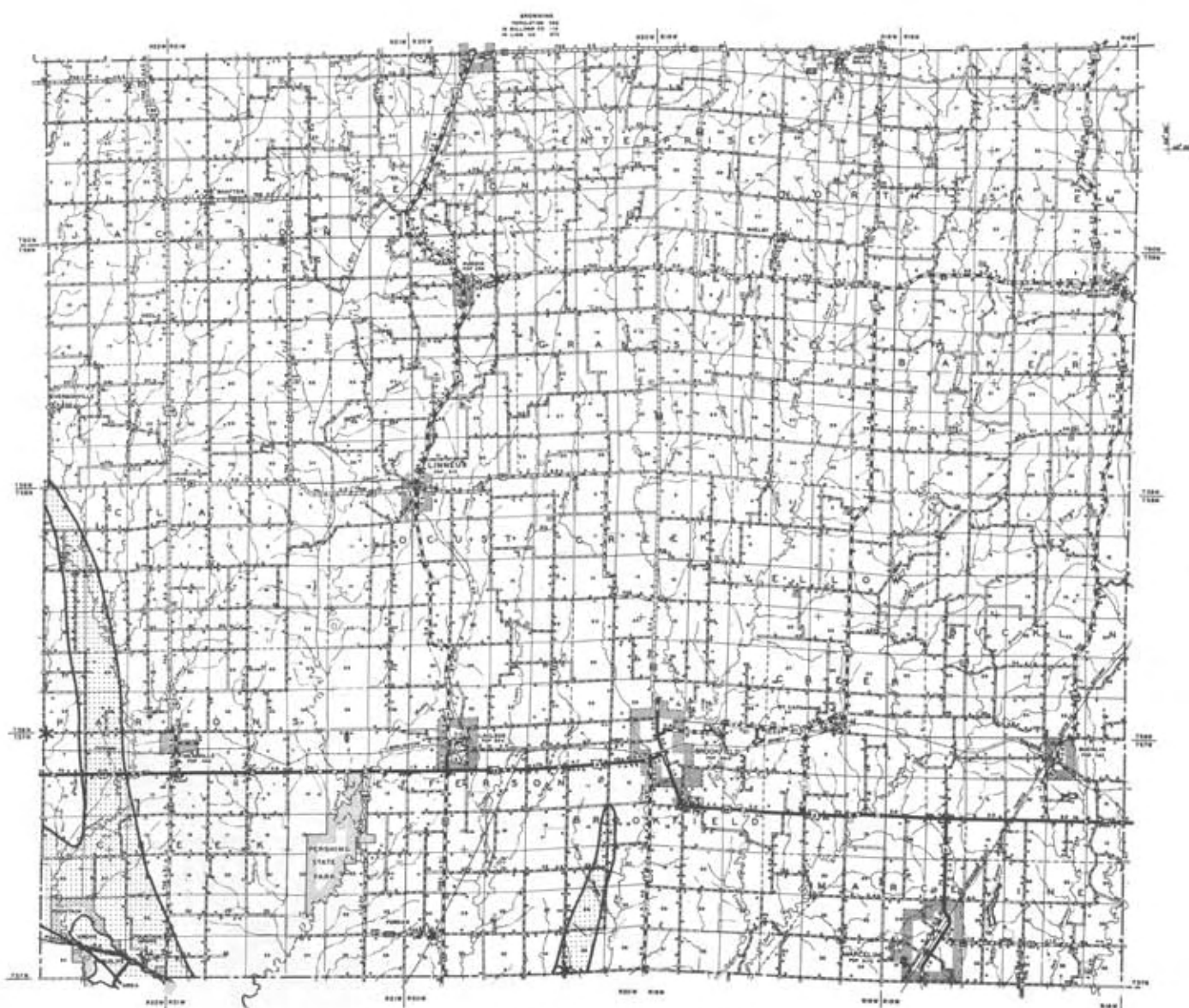
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ROLLA, MISSOURI

THOMAS R. BEVERIDGE  
STATE GEOLOGIST



Base by the Missouri State Highway Department, 1954

# LEGEND



Drift filled valley



Test wells that flowed

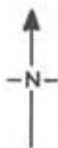


PLATE 2

## MAP OF LINN COUNTY

SHOWING

DRIFT FILLED VALLEYS IN WHICH  
IRRIGATION WELLS POSSIBLY CAN  
BE DEVELOPED

BY

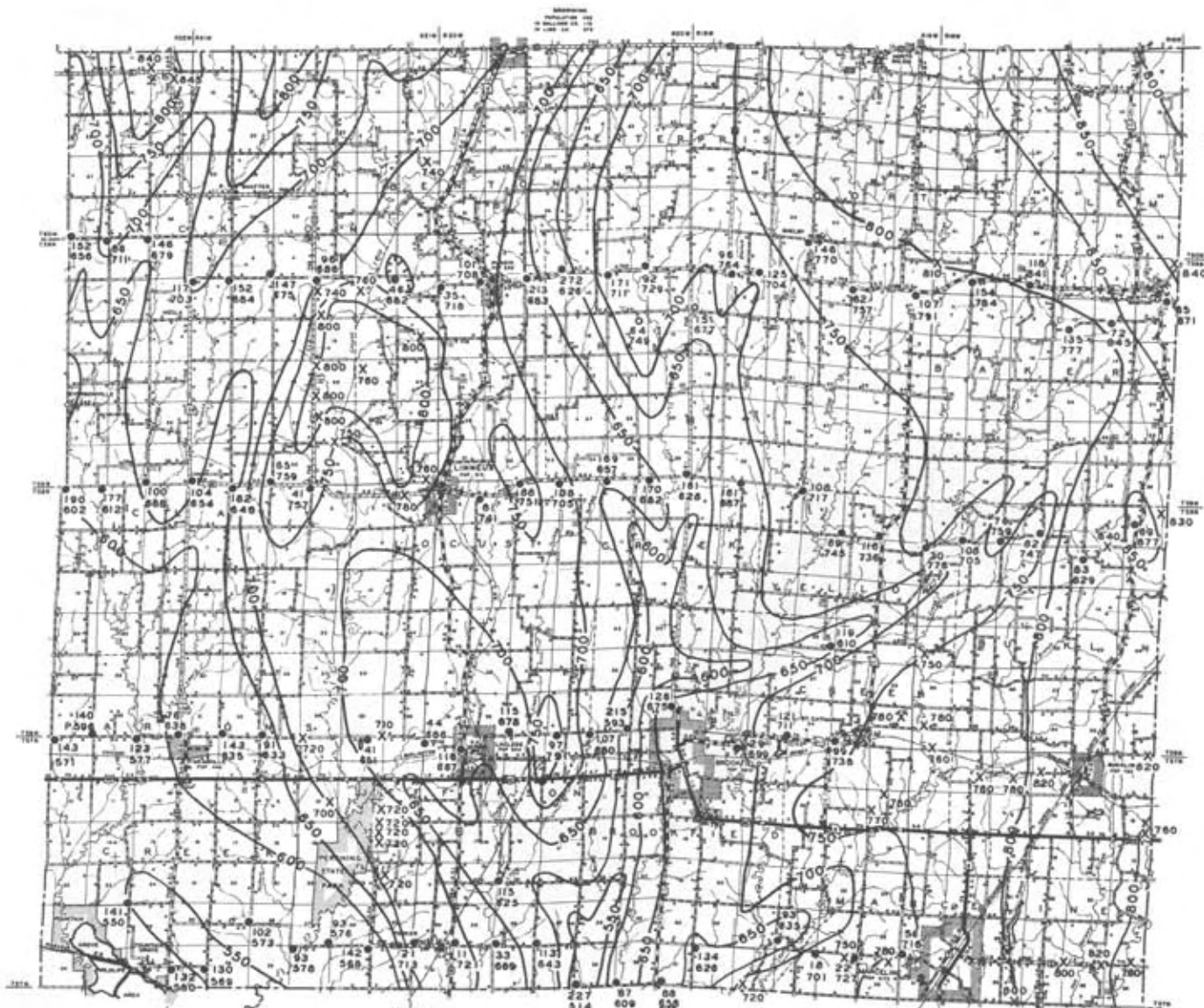
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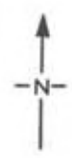




Base by the Missouri State Highway Department, 1954

**LEGEND**

- 135  
150 Test holes showing thickness in feet of drift and elevation of bedrock above sea level
- o Water wells
- X Bedrock Outcrops
- X Mine or Quarry
- 920 Indicates outcrop elevation



**PLATE 3**

**CONTOUR MAP  
OF  
LINN COUNTY  
SHOWING  
BEDROCK ELEVATIONS**

BY  
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JACK S. WELLS

1957  
MISSOURI GEOLOGICAL SURVEY  
AND WATER RESOURCES  
ROLLA, MISSOURI  
THOMAS R. BEVERIDGE  
STATE GEOLOGIST

## SUMMARY

Approximately 10,000 acres of Linn County are located within the area in which irrigation wells possibly can be developed. Approximately three-fifths of Linn County's area is suitably located for obtaining water sufficient for domestic needs from the glacial drift.

Questions concerning water problems for a specific location should be sent to the Missouri Geological Survey, Box 250, Rolla, Missouri 65401.